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(54) EARTH BORING TOOL WITH IMPROVED INSERTS

(71) We, HUGHES TOOL COMPANY, a company organized and existing under the laws of the State of Delaware, United States of America, having a place of business at 5425 Polk Avenue, Houston, Texas, 77023 United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates in general to earth boring tools and in particular to improved tungsten carbide inserts and methods for their manufacture to improve retention in interferingly sized holes and to decrease the frequency of fracture of the inserts.

Earth boring tools include those which have tungsten carbide inserts interferingly retained in mating holes, with protruding ends formed as rock cutting, crushing, chipping or abrading elements. A typical insert is manufactured of sintered tungsten carbide, a composition of mono and/or ditungsten carbide cemented with a binder selected from the iron group, consisting of cobalt, nickel or iron. Cobalt ranging from about 10 to 16% is presently the most common binder, the balance being tungsten carbide. The exact composition depends upon the usage intended for the tool and its inserts.

Most of the prior art inserts have ground cylindrical surfaces dimensioned to be larger than their mating drilled and reamed holes by a nominal value of about .002 inch. For the purpose of improving the surface finish and condition, the inserts are commonly "bright tumbled", meaning that they are tumbled against each other until their surfaces are smoothed to a condition that appears bright or shiny. Also, the inserts have in the past been tumbled in an abrasive medium such as aluminum oxide to produce a "mat" finish, which is relatively smooth but dull in comparison with a "bright" finish.

The smooth, bright and mat finishes were thought to be advantageous in minimizing, during insertion or pressing, the possibility of shearing the metal forming the surface of the interfering hole. Shearing of the retaining surface decreases the pressure exerted against an insert, and may cause loss of the insert during earth boring operations.

Frank E. Stebley in U.S. Patent No. 3,581,835, issued June 1, 1971, disclosed a generally polygon shaped insert abraded by barrel tumbling in the conventional manner in an abrasive medium that includes aluminum oxide and silicon rock wetted with a basar-water solution. Alternatively, the inserts may be grit blasted while set on end in a rubber mat to hasten abrasion. This abrasion is followed by tumbling in an abrasive medium to provide the desired smooth finish. The polygon shape prevents turning and movement of the insert, while the treatment with abrasives rounds the corner surfaces to prevent scraping of the wall of a retaining hole.

According to one aspect of the invention there is provided, in an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a finish on said surface obtained by abrading the insert with abrasive particles having hardness greater than 9.0 on Mohs Scale.

The invention also provides, in an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a surface randomly roughened to achieve asperities in a range varying from a maximum value, which is essentially smaller than that formed by grinding with a diamond wheel, to a minimum value, which is essentially larger than that of the mat finish obtained by abrading with aluminium oxide.

The invention further provides, in an earth penetrating tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a surface of the insert conditioned for improved retention in the interferingly mating hole by

tumbling multiple inserts in a particulate medium of essentially boron carbide.

The invention further provides, in an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a retaining surface of the insert roughened such that in any lineal increment of at least 0.010 inch, there are at least three asperities which from peak to trough are at least 0.001 inch long and at least 0.00005 inch deep when measured with a stylus point with a 0.0005 inch radius.

The invention further provides an improved method of manufacturing earth boring tools using sintered tungsten carbide inserts as either cutting, chipping, crushing or abrading elements, which are secured with interference fit by holes that are normally drilled and reamed, the method comprising the step of abrading the inserts with particles having hardness greater than 9.0 on Mohs Scale.

The invention further provides an improved method of manufacturing earth boring tools using sintered tungsten carbide inserts either as cutting, chipping, crushing or abrading elements, which are secured with interference fit by holes that normally are drilled and reamed, the method comprising the step of slurry tumbling multiple inserts with abrasive particles having a hardness greater than 9.0 on Mohs Scale.

The invention further provides an improved method of manufacturing earth penetrating tools using sintered tungsten carbide inserts, which are secured with interference fit in mating holes, the method comprising the step of roughening retaining surfaces of the inserts such that any lineal increment of at least 0.010 inch has at least three asperities which from peak to trough are at least 0.001 inch long and at least 0.00005 inch deep when measured with a stylus point with a 0.0005 inch radius.

In the accompanying drawings:

Figure 1 shows a rotary percussion type earth boring drill bit containing improved inserts according to the principles of the invention;

Figure 2 is a perspective view of a sintered tungsten carbide insert of the type used in the drill bit of Figure 1;

Figure 3 is a fragmentary sectional view of a rolling cone cutter with sintered tungsten carbide inserts used as earth disintegrating teeth; and

Figures 4 and 5 are charts depicting the surface condition respectively of a prior art ground and bright tumbled insert and an insert having a surface conditioned according to the invention.

Referring initially to Figure 1, the numeral 11 designates a rotary percussion earth boring drill bit having a typical splined shank 13 on its upper end. An enlarged lower region 15 has a plurality of sintered tungsten carbide inserts 17 secured by interference fit in mating holes drilled in selected locations in a transverse face 19. An air course 21 and return flow slots 23 on the outer periphery of the enlarged region 15 flush earth cuttings from the bottom of the bore hole.

An insert to which the invention is applied is shown in Figure 2. A typical geometrical configuration is illustrated for this insert 17, including a cylindrical wall surface 25, a perpendicular end 27 with a bevel 29, and a hemispherical end 31. The preferred metallurgical composition is sintered tungsten carbide having about 12% cobalt by weight, the balance being essentially monotungsten carbide. The bevel 29, as seen in longitudinal cross section, forms a preferred angle of about 15° with wall surface 25. Such constructions and composition are common in the prior art. Other insert shapes are within the scope of the invention as defined in the claims.

The drilled holes that receive the inserts are typically reamed in the prior art percussion bit and may have a surface finish of about 125 R.M.S. The bit may be formed from A.M.S. 6418 alloy steel, quenched and tempered to produce a hardness in a range from 37 to 44 Rockwell "C". These treatments and conditions are also known in the prior art.

The present invention may be obtained by a method that utilizes inserts 17 that have been ground initially with a centerless grinder with a 100 grit diamond 7-1-74 wheel, and subsequently slurry tumbled in a barrel tumbler containing particles of boron carbide and water. A majority of the particles are preferably 100 to 325 mesh, ideally 230 mesh, the mesh standard being that established by the United States Bureau of Standards. The inserts are tumbled with these particles from one half to two hours, ideally for about one hour. Then the inserts are pressed into the previously described drilled and reamed holes with a nominal interference of about 0.002 inch. Tolerances of the inserts and drilled holes enable the interference to vary normally in a range from 0.001 to 0.0028 inch.

The above described surface treatment produces surfaces that are randomly roughened to a maximum value of asperity, which is smaller than that obtained formed by the above-mentioned grinding operation, to a minimum value, which is larger than that of the mat finish obtained by abrading with aluminum oxide. This range of roughness may be visualized with reference to Figures 4 and 5, which are taken from charts produced through use of a diamond tipped stylus having a rounded tip with a 0.0005 inch radius. Figure 4 shows the surface condition detected by moving the stylus across the sur-

face of a prior art, ground and bright tumbled insert. Figure 5 shows the surface condition of an insert having a surface condition produced according to the invention. It may be seen in Figure 5 that in any lineal surface distance of at least 0.010 inch there are at least three general asperities which from peak-to-trough measure at least 0.001 inch long (measured along the horizontal axis) and at least 0.00005 inch deep (measured along the vertical axis). There are usually minor asperities seen in one general asperity, as for example the minor asperity 32 seen in the general asperity 34 of Figure 5.

The invention is also applied to inserts 36 (Figure 3) used in interferingly sized holes in a rolling cutter 33 supported on a bearing pin 35 of a rotary cutter drill bit. A typical prior art insert arrangement and bearing configuration are shown.

Utilization of the invention produces unexpected results in improved insert retention and reduced frequency of insert breakage. The force required to press an insert into a hole is increased by as much as 100 percent in laboratory tests. The press-out force is increased by as much as 50 percent. Field test showed a significant decrease in the number of inserts which fractured during earth drilling.

The particular abrasive particle may be varied if hardness is sufficient. From page 61 of the Metals Handbook, 1948 Edition, The American Society for Metals, appears the following table:

TABLE I

Relative Abrasive Action of Diamond and Similar Substances on Sintered Carbide

Diamond dust on sintered carbide	1000
Boron carbide on sintered carbide	600
Boron on sintered carbide	480
Silicon carbide on sintered carbide	220
Aluminum oxide on sintered carbide	40

Page F-18 of the Handbook of Chemistry and Physics, 51st Edition, The Chemical Rubber Company, provides the following table [upper portion of table deleted]:

Comparison of Hardness Values of Various Materials on Mohs and Knoop Scales

Substance	Formula	Mohs value	Knoop value
Alumina	Al_2O_3	—	2100
Beryllium carbide	Be_2C	—	2410
Titanium carbide	TiC	—	2470
Silicon carbide	SiC	—	2480
Aluminum boride	AlB	—	2500
Boron carbide	B_4C	—	2750
Diamond	C	10	7000

In addition to the materials of the above tables, cast tungsten carbide (an alloy of WC and W_2C) has been measured to have a Knoop hardness of 2300 to 2600 KHN, and boron measures 9.5 on Mohs Scale. Carbides of tungsten such as W_2C and mixtures of WC and W_2C are harder than 9.0 on Mohs Scale and harder than sintered tungsten carbide which with a cobalt binder is measured to be 1400—1800 KHN on the last table above in its complete form. The term "tungsten carbide" as used herein refers to carbides of tungsten and does not include sintered (cemented) tungsten carbide.

Aluminum oxide (alumina) produces a surface that is too smooth, having the "mat" appearance previously discussed. The harder particles produce a surface that significantly improves retention and decreases the frequency of insert breakage during earth boring operations.

The reason why the invention is successful is not fully understood. It is known that the treatment of the inserts eliminates all sharp corners at the intersection of the bevel 29 (see Figure 2) and cylindrical surface 25. This rounding of the intersection minimizes shearing of the surface of a drilled hole upon assembly with the insert. Also, the roughened surface of the insert falls within an upper and a lower limit. The upper limit of roughness, produced by grinding with a diamond wheel in the prior art, causes shearing of the surface of the hole. The lower limit of roughness, defined by abrading with aluminum oxide particles, is too smooth for the most effective insert retention, and for unknown reasons, does not reduce the frequency of insert breakage. The more firmly an insert is retained, assuming the retaining metal is not stressed excessively, the less likelihood there is of breakage in operation.

While the invention has been shown and described in only one of its forms, it should be understood that it is not to be thus limited, but is susceptible to various changes and modifications within the scope of the invention as defined in the claims. Its use is not limited, for example, the preferred geometries and constructions shown and described.

The earth boring bit shown in Figure 1 is described in greater detail in co-pending

Patent Application No. 22377/75 (Serial No. 1,507,163) and claimed from other aspects thereof.

WHAT WE CLAIM IS:—

1. In an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a finish on said surface obtained by abrading the insert with abrasive particles having hardness greater than 9.0 on Mohs Scale.

2. The invention defined by claim 1 wherein said abrasive particles are selected from beryllium carbide, titanium carbide, silicon carbide, aluminum boride, cast tungsten carbide, ditungsten carbide, boron carbide, boron and diamond.

3. The invention defined by claim 1 wherein said abrasive particles are essentially boron carbide.

4. The invention of claim 2 wherein the majority of the particle sizes are in a range from 100 to 325 mesh.

5. In an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a surface randomly roughened to achieve asperities in a range varying from a maximum value, which is essentially smaller than that formed by grinding with a diamond wheel, to a minimum value, which is essentially larger than that of the mat finish obtained by abrading with aluminum oxide.

6. In an earth penetrating tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a surface of the insert conditioned for improved retention in the interferingly mating hole by tumbling multiple inserts in a particulate medium of essentially boron carbide.

7. The invention of claim 6 wherein a majority of the boron carbide particles are in a range from 100 to 325 mesh.

8. In an earth boring tool, an improved sintered tungsten carbide insert with a surface interferingly secured to the wall of a retaining hole, the improvement comprising a retaining surface of the insert roughened such that in any lineal increment of at least 0.010 inch, there are at least three asperities which from peak to trough are at least 0.001 inch long and at least 0.00005 inch deep when measured with a stylus point with a 0.0005 inch radius.

9. An improved method of manufacturing earth boring tools using sintered tungsten carbide inserts as either cutting, chipping, crushing or abrading elements, which are secured with interference fit by holes that normally are drilled and reamed, the method comprising the step of abrading the inserts with particles having hardness greater than 9.0 on Mohs Scale.

10. The method defined by claim 9 wherein said particles are selected from beryllium carbide, titanium carbide, silicon carbide, aluminum boride, cast tungsten carbide, ditungsten carbide, boron carbide, boron and diamond.

11. The method defined by claim 10 wherein said particles are essentially boron carbide.

12. An improved method of manufacturing earth boring tools using sintered tungsten carbide inserts as either cutting, chipping, crushing or abrading elements, which are secured with interference fit by holes that normally are drilled and reamed, the method comprising the step of slurry tumbling multiple inserts with abrasive particles having a hardness greater than 9.0 on Mohs Scale.

13. The method defined by claim 12 wherein said particles are selected from beryllium carbide, titanium carbide, silicon carbide, aluminum boride, cast tungsten carbide, ditungsten carbide, boron carbide, boron and diamond.

14. The method of claim 13 where the particles are essentially boron carbide.

15. The method of claim 14 wherein a majority of the particles are in a range from 100 to 325 mesh.

16. An improved method of manufacturing earth penetrating tools using sintered tungsten carbide inserts, which are secured with interference fit in mating holes, the method comprising the step of roughening retaining surfaces of the inserts such that any lineal increment of at least 0.010 inch has at least three asperities which from peak to trough are at least 0.001 inch long and at least 0.00005 inch deep when measured with a stylus point with a 0.0005 inch radius.

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Agents for the Applicants.

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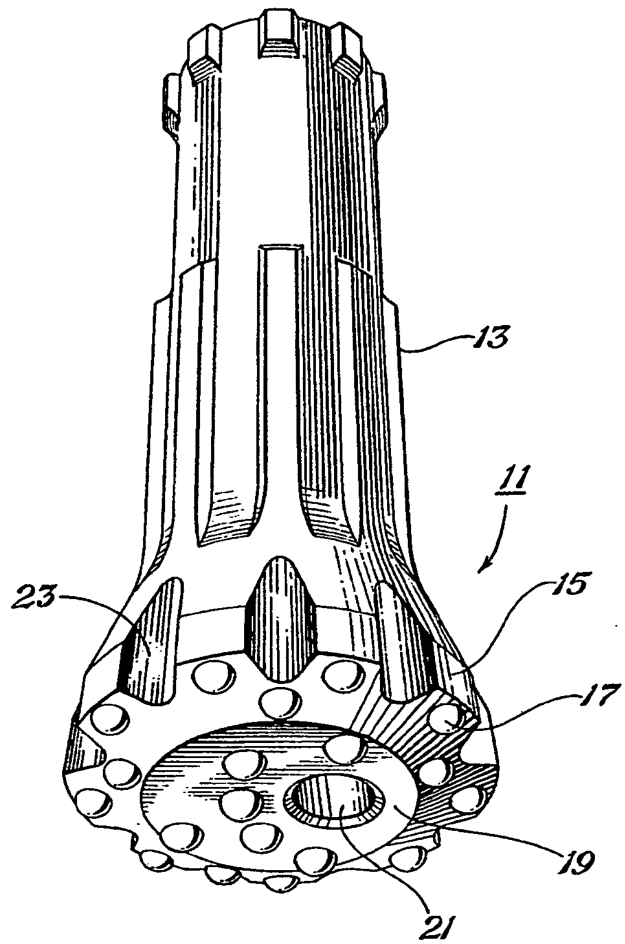

Fig. 1

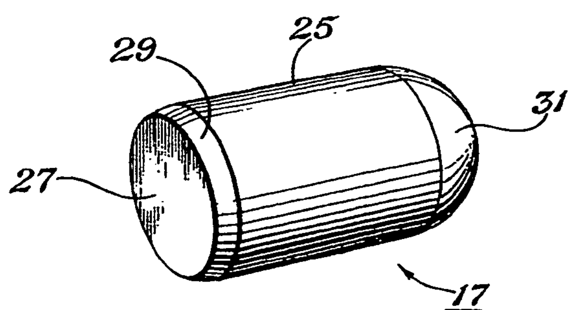

Fig. 2

Fig. 3

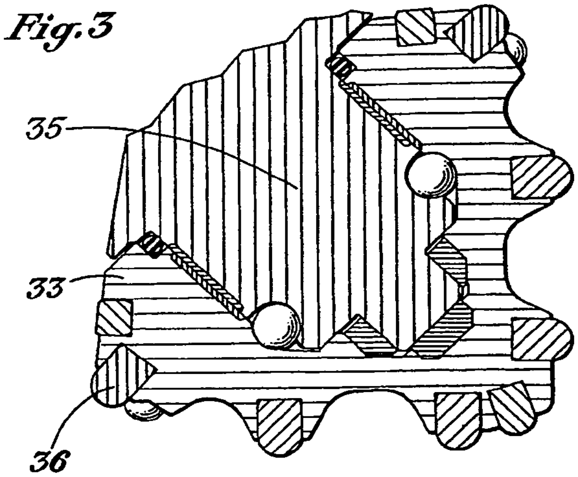

Fig. 4

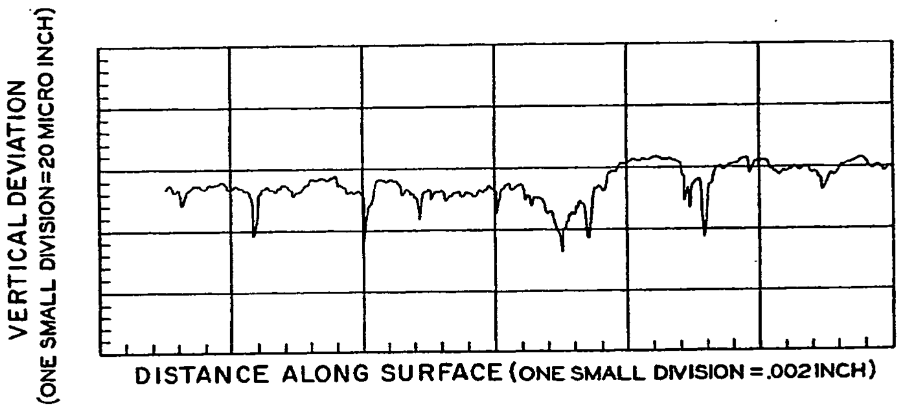

Fig. 5